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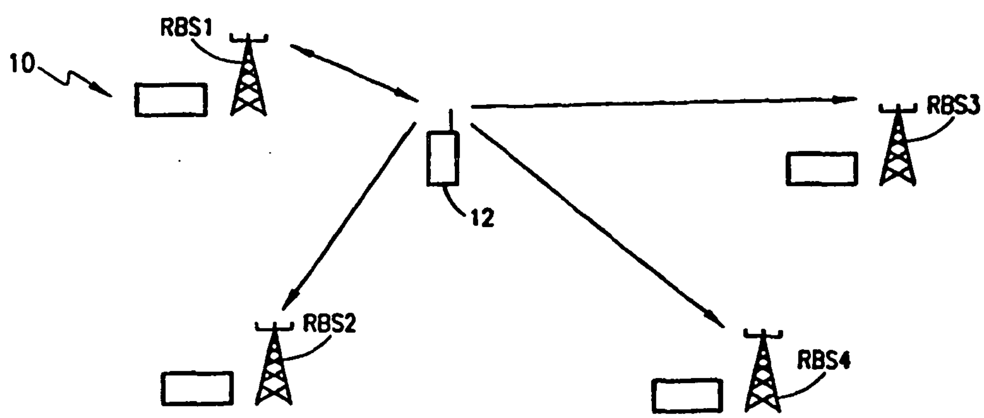

(57) Abstract

A method and system are diclosed for time-synchronizing a plurality of radio base stations (RBS1-4) in a cellular communications network. A reference terminal (106) (e.g., modified standard mobile terminal) is placed at known locations at each RBS site in the network, preferably as close to the base station antenna (104) as possible. The reference terminal (106) includes an absolute time reference function, which is used to synchronize the RBSs (102) with respect to a common absolute time reference. Consequently, a positioning algorithm can be used to determine the position of a mobile terminal (12) in the network with a relatively high degree of accuracy.

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ABSOLUTE TIME SYNCHRONIZATION FOR MOBILE POSITIONING IN A CELLULAR COMMUNICATIONS SYSTEM

BACKGROUND OF THE INVENTION

Technical Field of the Invention

The present invention relates in general to the mobile communications field and, in particular, to a method and system for accurately determining the position of mobile terminals (MTs) in a cellular communications system.

Description of Related Art

The prior art discloses numerous methods for determining the geographical position of a MT in cellular communications systems. Some existing positioning methods use the arrival time of the signal transmitted from a MT at the radio base stations (RBSs), as the basis for the positioning calculations. These methods are typically referred to as Time of Arrival (TOA) or Time Difference of Arrival (TDOA) measurement approaches. For example, at a common measurement instant, several RBSs measure the arrival time of a signal received from a MT whose position is to be determined. A central computing function converts the different arrival times of the MT's signal to distances, and calculates the results to determine the position of the MT. The precision in this TOA method is determined primarily by the exactness of the burst arrival time at each RBS, with respect to a common time reference. Essentially, for high precision, the RBSs need to receive a highly accurate time reference signal, and the delays in their respective receive antenna signal paths have to be known.

FIGURE 1 is a simplified block diagram that illustrates a typical prior art time of arrival MT positioning system (10). As shown, the MT 12 whose position is to be determined is synchronized to the RBSs (RBS1-4). The network orders the MT 12 to generate and transmit one or more bursts. Each RBS (RBS1-4) measures the respective arrival time of a burst received from the MT 12. The RBSs

determine the respective arrival times in comparison with a common time reference, and report the respective arrival times to a central node in the network. A processor in the central node calculates the position of the MT, based on the reported arrival times.

One solution proposed to keep track of the absolute time in a cellular system is based on calibration of antenna delays and the use of an absolute time unit (ATu) connected to each RBS. For example, an ATu connected to an RBS can comprise a Global Positioning System (GPS) receiver. The calibration data thus derived is stored in a database in the RBS.

A significant problem with the above-described absolute time approach is that the absolute time information needs to be distributed from the ATu to the receiving part of an RBS with a known delay. However, a number of different RBS implementations exist, so the delay characteristics for each distribution path need to be known. In addition, the delay between the RBS receiver and antenna needs to be known, along with delays within the receiver. The specific antenna installation and receiver implementation used results in a delay that varies widely with the type of installation, operating temperature, age of equipment, type of receiver, type of connecting cables, etc. As such, the number of such delay variables implies that use of such a one-time calibration procedure would provide a time resolution with an unknown accuracy. Also, such an absolute time approach would be difficult to introduce into already existing RBSs without performing a major redesign.

In addition to the MT positioning approaches described above, synchronization of different base stations to a common "air frame structure" has been considered useful for many applications, such as simplified handovers of MTs between base stations, MT positioning, etc. One approach that can be used for base station synchronization to a common air interface frame structure is terminal-based mobile positioning. For example, one such positioning method uses the arrival time at an MT of the signals generated by the RBSs as the basis for the MT's positioning calculations. The MT whose position is to be determined measures (at a given instant) the arrival times of as many received RBS signals as the MT can "hear," and calculates the difference in arrival times between the bursts. The MT sends the

difference in arrival time information to its serving RBS, which sends the information to the system node that includes the MT positioning calculation function. The precision of this method is determined by the exactness of the arrival time measurements in the MT, and knowledge of the time difference between each RBS.

Referring again to FIGURE 1, if all of the RBSs shown are synchronized together, this means that the air interface from each RBS is generated from a common time reference and can be replicated with relatively high accuracy via the transmitter's antenna system. The MT being positioned "listens" to the broadcast channels from the different RBSs, measures the arrival times of the bursts, and calculates the difference in the delays between them.

One such proposed terminal-based approach is to place reference terminals at known locations between the RBSs. The reference terminals can utilize the same positioning algorithm as the MT being positioned to perform a comparative position calculation. As such, this approach would solve the above-described problem of varying RBS delays and non-synchronized RBSs.

However, a significant problem with the above-described approach is that the reference terminals located between the different RBSs would require sites with complex power and climate controls, etc. Also, finding an appropriate location for the reference terminal equipment, and monitoring their operation will be problematic.

Furthermore, synchronizing the different RBSs is problematic because of the variations between the different RBS implementations. As described earlier, the absolute time information needs to be distributed from the ATu to the receiving part of an RBS with a known delay.
However, a number of different RBS implementations exist, so the delay characteristics for each distribution path need to be known. In addition, in this case, the delay between the transmitter and antenna needs to be known, along with delays within the transmitter. The specific antenna installation and transmitter implementation used results in a delay that varies widely with the type of installation, operating temperature, age of equipment, type of transmitter, type of

connecting cables, antenna combining equipment, etc. Similar to the RBS-based absolute time approach described above, the number of such delay variables implies that use of such a one-time calibration procedure would provide a time resolution with an unknown accuracy. Also, such an absolute time approach would be difficult to introduce into already existing RBSs without performing a major redesign.

SUMMARY OF THE INVENTION

In accordance with a preferred embodiment of the present invention, a method and system are provided for time-synchronizing a plurality of radio base stations in a cellular communications network. A reference terminal (e.g., modified standard mobile terminal) is placed at known locations at each RBS site in the network, preferably as close to the base station antenna as possible. The reference terminal includes an absolute time reference function, which is used to synchronize the RBSs with respect to a common absolute time reference. Consequently, a positioning algorithm can be used to determine the position of a mobile terminal in the network with a relatively high degree of accuracy.

An important technical advantage of the present invention is that no new hardware interfaces are introduced between an RBS and its associated reference terminal.

Another important technical advantage of the present invention is that all time-critical components are concentrated in one unit, so that a new positioning system based on the present invention can be introduced in an existing RBS without replacing existing RBS equipment.

Still another important technical advantage of the present invention is that time of arrival measurements can be calculated with respect to the radio air interface (i.e., at the antenna), which makes the MT positioning algorithm insensitive to different RBS delay variations.

Yet another important technical advantage of the present invention is that the method can be used for antenna supervision both for the uplink and downlink.

Still another important technical advantage of the present invention is that

positioning measurements can be made independently of delays in the antenna system.

Still another important technical advantage of the present invention is that the method can be used for accurate Time Division Multiple Access (TDMA) frame synchronization between RBSs.

Still another important technical advantage of the present invention is that RBSs being used for position determinations can be temporarily located at interim locations (e.g., fairs, sports events, etc.)

Still another important technical advantage of the present invention is that the reference terminals can be used as a type of positioning reference terminal for terminal-based MT positioning.

Still another important technical advantage of the present invention is that a mobile RBS with a satellite link interface can be used as a mobile "tracker" in a positioning system, whereby a reference terminal can function as a user interface to the position algorithm function.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the method and apparatus of the present invention may be had by reference to the following detailed description when taken in conjunction with the accompanying drawings wherein:

FIGURE 1 is a simplified block diagram that illustrates a typical prior art time of arrival MT positioning system;

FIGURE 2 is a simplified block diagram that illustrates an exemplary system for time-calibrating a radio base station in a cellular communications network, in accordance with a preferred embodiment of the present invention;

FIGURE 3 is a sequence diagram that illustrates an exemplary method that can be used to update the absolute time information in a radio base station shown in FIGURE 2, in accordance with the preferred embodiment of the present invention;

FIGURE 4 is a sequence diagram that illustrates an exemplary time of arrival measurement sequence that can be used initially (e.g., at system set-up) for

determining the position of a base station in a cellular communications network, in accordance with the preferred embodiment of the present invention; and

FIGURE 5 is a sequence diagram that illustrates an exemplary time of arrival measurement sequence that can be used while determining the position of mobile terminals in a cellular communications network, in accordance with the preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE DRAWINGS

The preferred embodiment of the present invention and its advantages are best understood by referring to FIGUREs 2-5 of the drawings, like numerals being used for like and corresponding parts of the various drawings.

FIGURE 2 is a simplified block diagram that illustrates an exemplary system (100) for time-calibrating a radio base station in a cellular communications network, in accordance with a preferred embodiment of the present invention. System 100 includes an RBS 102 coupled to an antenna subsystem 104. For explanatory purposes, the exemplary system 100 shown is described as part of a Global System for Mobile Communications (GSM) network. However, the invention is not intended to be limited to the GSM and can include any appropriate cellular network that utilizes radio signal timing (e.g., TDMA) to determine the position of mobile terminals. Also, although only one exemplary system 100 for time-calibrating an RBS (102) is shown, system 100 can be duplicated in a plurality of similar systems for time-calibrating other RBSs (not shown) in a cellular communications network.

System 100 also includes a reference terminal (RT) 106 coupled preferably by a wireline connection 108 to the RBS 102. Connection 108 can provide power for RT 106 from RBS 102. Optionally, connection 108 can provide data communications therebetween, but the full technical advantages of the present invention would not be realized since added hardware (data interface) would be required.

RT 106 can be a modified, standard MT. For this embodiment, RT 106 is an MT with a calibrated transmission delay. For example, the internal delays inherent in RT 106 are predetermined and stored locally for calibration purposes,

along with the delay characteristics of the antenna cable 110. Cable 110 (with the known delay) couples RT 106 to a transmit/receive antenna 112. For this exemplary embodiment, antenna 112 is a combined GSM transmit/receive antenna section and GPS receive antenna section.

In addition to standard MT components, RT 106 also includes an absolute time reference unit (not shown). For this embodiment, the absolute time reference unit can be a GPS receiver. Consequently, the RT 106 can receive highly accurate timing signals and/or absolute position information for the RT 106 from the GPS receiver. Consequently, if the RT 106 is co-located with, or a known distance and direction from the RBS 102, the RBS's absolute position is also known. The GPS receiver in the RT 106 can be synchronized with a phase-locked loop (PLL) in the RT. The absolute time information thus derived with the PLL from the absolute time reference unit is used by a processor in the RT 106 to mark precisely the instant in time when the RT transmits each burst over the air interface. The RT stores this burst timing information in local memory, and also forwards this absolute time information (e.g., burst X transmitted at time T) to the RBS 102 preferably via the radio air interface. The burst timing information can also be forwarded to other network components by the RBS 102 using a standard message transfer protocol. As described in more detail below, the respective absolute burst timing information known by each of a plurality of RBSs in a cellular network can be used by a TOA or TDOA positioning algorithm to more accurately determine the position of a mobile terminal.

FIGURE 3 is a sequence diagram that illustrates an exemplary method that can be used to update the absolute time information in the RBS 102 shown in FIGURE 2 (or any similar network RBS), in accordance with the preferred embodiment of the present invention. As shown for explanatory purposes, the absolute time updating method 200 is applied to RBSb (e.g., RBS 102 in FIGURE 2) and its associated RT (e.g., RT 106). However, the method can also be applied to update the absolute time information in each of the other network RBSs (e.g., RBSc 102' and RBSa 102").

At step 202 of the exemplary method, the RBS 102 connects with the RT 106 (e.g., preferably via the radio air interface) and orders the RT 106 to generate a burst for transmission (measurement- or M-burst). In response, the RT 106 reads in (e.g., via the PLL coupled to the GPS receiver) the absolute time, and simultaneously transmits the M-burst over the air interface via antenna unit 112. Also, the RT 106 stores the M-burst's reference absolute time value (absolute transmit time of the burst, or At_0) in local memory.

At step 204, the transmitted M-burst is received by the RBS 102 via antenna subsystem 104. The RBS 102 measures the arrival time of the received M-burst, and relates that measured arrival time value to an Absolute Time Counter (AT-CNT) value stored in the RBS. The arrival time of the received M-burst (At_1) is stored in local memory in the RBS 102.

At step 206, the RBS 102 connects (preferably via the radio air interface) with its associated RT 106 and requests the M-burst transmit time information (At_0). In response, at step 208, the RT 106 sends the requested information preferably via the air interface to the RBS 102. The RBS 102 (an internal processor) then calculates the difference between the M-burst's transmit reference time value (At_0) and received arrival time value (At_1). The processor in the RBS 102 uses the difference value (Δt) to update the absolute time value in the AT-CNT with the difference value (Δt) and thus compensate for any pre-existing time error. Between M-burst updates, which can occur periodically, the RBS 102 uses the AT-CNT to continue providing the absolute time by counting internal clock periods (e.g., the AT-CNT can "free-wheel" in-between the periodic absolute time updating or calibrating events, by use of the internal TDMA clock). As such, for MT positioning purposes, the time of arrival for signals received from an MT whose position is to be determined can be based on the highly accurate absolute time reference provided by the present invention, as measured at the receive antenna port of the RBS(s) involved. In other words, the reference point for the highly accurate time of arrival measurement is at the receive antenna port for the RBS involved. Consequently, in accordance with the present invention, the delay between the receive antenna (e.g., 104) and the RBS (102) has been compensated for.

In a different aspect of the preferred embodiment, the following method can be used to synchronize the TDMA operations in a network of RBSs. A network base station controller (BSC) or mobile services switching center (MSC) sends a message to all RBSs involved (e.g., each similar to RBS 102), which orders the RBSs to time-align the generation of TDMA slots and transmissions based on a given absolute start time value (TDMA-start). Each RBS uses the AT-CNT value described above to await the TDMA-Start command and start (or adjust) the respective RBS's TDMA counter. The above-described absolute time-counter updating method 200 can also be used to enhance the precision of the TDMA timing in the network. The network BSC (or MSC) can request RBSs to provide their respective TDMA counter values at known absolute times, in order to monitor the precision of network synchronization.

In a terminal-based variation of this aspect of the present invention, each RT locked to its respective RBS can continuously measure the arrival time of received bursts expressed as an absolute time value, and store the absolute time value in local memory. A central node (e.g., BSC or MSC in the GSM) orders the RTs to report back the absolute time of their respective RBSs' TDMA frame structure. A processor in the central node evaluates the time differences between the RBSs, and calculates a time offset for each RBS. The central node sends a respective time offset as a control parameter to the pertinent RBS, which uses the time offset to adjust its air timing generator accordingly and minimize the time error at the transmitter antenna point. As such, the TOA of bursts received by an MT from these time-calibrated RBSs can be used by a positioning algorithm to more accurately determine the position of the MT.

The central node may order the RTs periodically to report the absolute time information for the TDMA structure for verification purposes, or at any time as part of a system supervisory function. The above-described terminal-based synchronization function can be performed in steps, such as, for example, first synchronizing the neighboring RBSs in the same cell, then synchronizing the neighboring RBSs in other cells. and so on until the entire network is synchronized. Consequently, this method will account for all of the delays in the antenna system,

and provide a complete "air interface sync."

FIGURE 4 is a sequence diagram that illustrates an exemplary time of arrival measurement sequence 300 that can be used initially (e.g., at system set-up) for determining the position of a base station in a cellular communications network, in accordance with the preferred embodiment of the present invention. Initially, at step 302, each RBS involved (e.g., RBS 102 in FIGURE 2) orders its associated RT (e.g., RT 106) via the air interface to send the RT's geographical position (e.g., X,Y or latitudinal and longitudinal coordinates), which can be derived from the RT's GPS receiver. In response, at step 304, the RT sends (preferably via the air interface) the requested position information to the RBS (102). The RBS reports this position information to a central positioning function in a network MSC, which can use the reported position information from each such RBS as a basis for MT positioning calculations.

FIGURE 5 is a sequence diagram that illustrates an exemplary time of arrival measurement sequence 400 that can be used while determining the position of MTs in a cellular communications network, in accordance with the preferred embodiment of the present invention. Sequence 400 can follow and/or be complementary to the time of arrival measurement sequence 300 described above with respect to FIGURE 4. At step 402, the RBS (e.g., RBSa 102") for the MT whose position is to be determined (e.g., MT 420) sends a control message over the air interface, which orders that MT to generate and transmit one or more timing measurement bursts (T-bursts). Also, the network BSC or MSC orders all of the RBSs involved in the position determinations (e.g., RBSb 102, RBSc 102', and RBSa 102") to perform a time of arrival measurement at a predetermined time, and each with a predetermined frequency and timeslot.

At step 404, each RBS receives the T-burst and measures its respective arrival time. Each RBS then relates the respective measured arrival time with the absolute time value in the respective AT-CNT. The resulting absolute time value associated with each respective measured arrival time is stored in each respective RBS's local memory (Mtime_0).

The following sequence of steps is virtually identical to the absolute time

updating sequence 200 described above with respect to FIGURE 3. However, the following sequence can be performed at each MT positioning event, in order to ensure that the delays experienced for the received burst are the same for the MT whose position is being determined (e.g., MT 420) and the RT for each RBS involved in the positioning events. Consequently, the sequence shown in FIGURE 5 can be used to compensate for delay differences caused by temperature variations and other variations between the different receivers.

At step 406, each pertinent RBS connects with its associated RT and orders the RT to generate one or more M-bursts. In response, each RT reads its absolute time reference (e.g., from a GPS receiver), transmits its M-burst, and stores the absolute time reference value (absolute transmit time of the burst, or At_0) in local memory. At step 408, the pertinent RBS receives the transmitted M-burst from the associated RT, measures the arrival time of that burst, and relates that measured arrival time value with the absolute time reference value in the AT-CNT. The RBS stores the resulting absolute time value for the measured arrival time (At_1) in local memory.

At step 410, the pertinent RBS connects with its associated RT and requests the transmission time of the M-burst (At_0). In response, at step 412, the pertinent RBS receives the transmission time value for the M-burst, and calculates the absolute arrival time for the T-burst, preferably with the expression: Abstime=At_0-(At_1-$Mtime_0$). The

RBS reports the calculated absolute time value to the central MT positioning function preferably in the network MSC. As such, the time of arrival measurements used in making MT position determinations are time-aligned precisely with the absolute time reference values provided by the present invention.

Although a preferred embodiment of the method and apparatus of the present invention has been illustrated in the accompanying Drawings and described in the foregoing Detailed Description, it will be understood that the invention is not limited to the embodiment disclosed, but is capable of numerous rearrangements, modifications and substitutions without departing from the spirit of the invention as set forth and defined by the following claims.

WHAT IS CLAIMED IS:

1. A method for time-synchronizing at least one radio base station in a cellular communications network, comprising the steps of:

a reference terminal associated with said at least one radio base station transmitting at least one measurement signal, and determining a reference time value for said transmission of said at least one measurement signal;

said at least one radio base station receiving said transmitted at least one measurement signal, and determining a time of arrival value for said received at least one measurement signal; and

said at least one radio base station updating said time of arrival value with said reference time value.

2. The method of Claim 1, further comprising the step of measuring the updated reference time of arrival value at a receive antenna port of said at least one radio base station.

3. The method of Claim 1, wherein said reference time value comprises an absolute time value.

4. The method of Claim 1, wherein said reference time value comprises a GPS-derived absolute time value.

5. The method of Claim 1, wherein said reference terminal includes an absolute time reference generator.

6. The method of Claim 5, wherein said absolute time reference generator comprises a GPS receiver.

7. The method of Claim 1, wherein said at least one radio base station comprises a GSM Radio Base Station.

8. The method of Claim 1, wherein the updating step comprises calculating a difference time value between said reference time value and said time of arrival, and compensating an absolute time counter value for said difference time value.

9. The method of Claim 1, further comprising the step of a network node ordering said at least one radio base station and a plurality of radio base stations to time-align generation of respective TDMA slots and transmissions to an absolute start time value.

10. The method of Claim 9, further comprising the step of measuring said absolute start time value of said TDMA transmissions at a transmitter antenna port of said at least one radio base station and said plurality of radio base stations.

11. The method of Claim 1, wherein the steps are applied to each one of a plurality of radio base stations in said cellular communications network; and further comprising the step of determining a position of a mobile terminal based on a plurality of said updated time of arrival values.

12. A method for time-synchronizing a plurality of radio base stations in a cellular communications network, comprising the steps of:

each one of a plurality of reference terminals reporting to a network node an absolute time value for a respective TDMA timing parameter;

a processor associated with said network node calculating a time offset value for each of said plurality of radio base stations, each said time offset value based on a comparison between each said absolute time value and said respective TDMA timing parameter; and

said network node sending a respective time update command to each of said plurality of radio base stations.

13. The method of Claim 12, further comprising the step of each of said

plurality of radio base stations adjusting a respective TDMA timing based on said respective time offset value from said network node to minimize a time error.

14. The method of Claim 12, further comprising the steps of:

each of said plurality of radio base stations adjusting a respective timing based on said respective time offset value from said network node to minimize a time error; and

determining a position of a mobile terminal based on a measurement of time of arrival of bursts received by said mobile terminal from each of said plurality of radio base stations.

15. A time-synchronized cellular communications network, comprising:

a plurality of radio base stations; and

a plurality of reference terminals, each of said plurality of reference terminals coupled to a respective one of said plurality of radio base stations and including means for transmitting at least one measurement signal and determining a reference time value for said transmission of said at least one measurement signal, each of said plurality of radio base stations including means for receiving said transmitted at least one measurement signal, determining a time of arrival value for said received at least one measurement signal, and updating said time of arrival value with said reference time value.

16. The cellular communications network of Claim 15, wherein said reference time value comprises an absolute time value.

17. The cellular communications network of Claim 15, wherein said reference time value comprises a GPS-derived absolute time value.

18. The cellular communications network of Claim 15, wherein each of said plurality of reference terminals includes an absolute time reference generator.

19. The cellular communications network of Claim 18, wherein said absolute time reference generator comprises a GPS receiver.

20. The cellular communications network of Claim 15, wherein said plurality of radio base stations comprise a plurality of GSM Radio Base Stations.

21. The cellular communications network of Claim 15, wherein said means for updating includes means for calculating a difference time value between said reference time value and said time of arrival, and updating an absolute time counter value with said difference time value.

22. The cellular communications network of Claim 15, further comprising a network node including means for ordering said plurality of radio base stations to time-align generation of respective TDMA slots and transmissions to a common start time value.

23. The cellular communications network of Claim 15, further comprising means for determining a position of a mobile terminal.

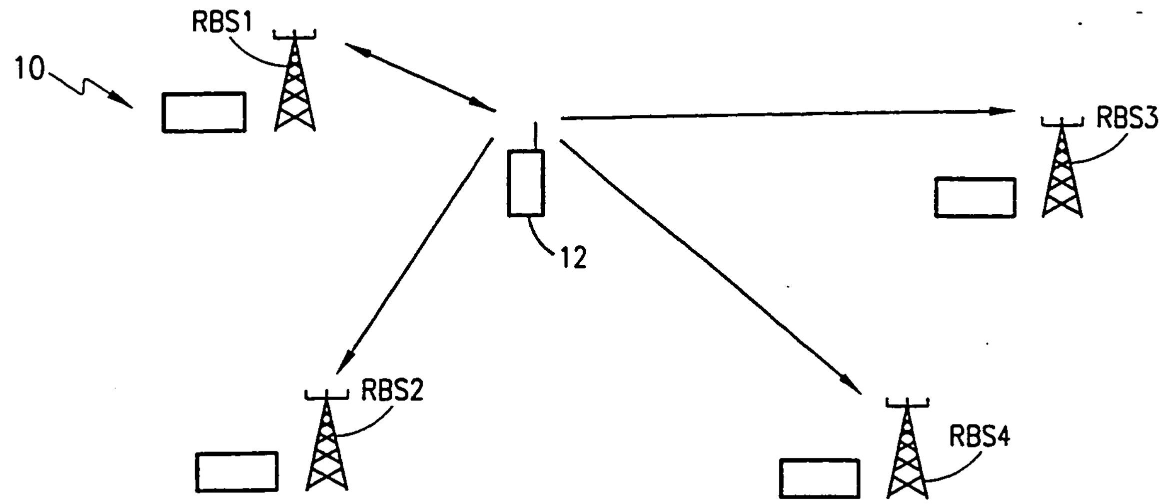

FIG. 1

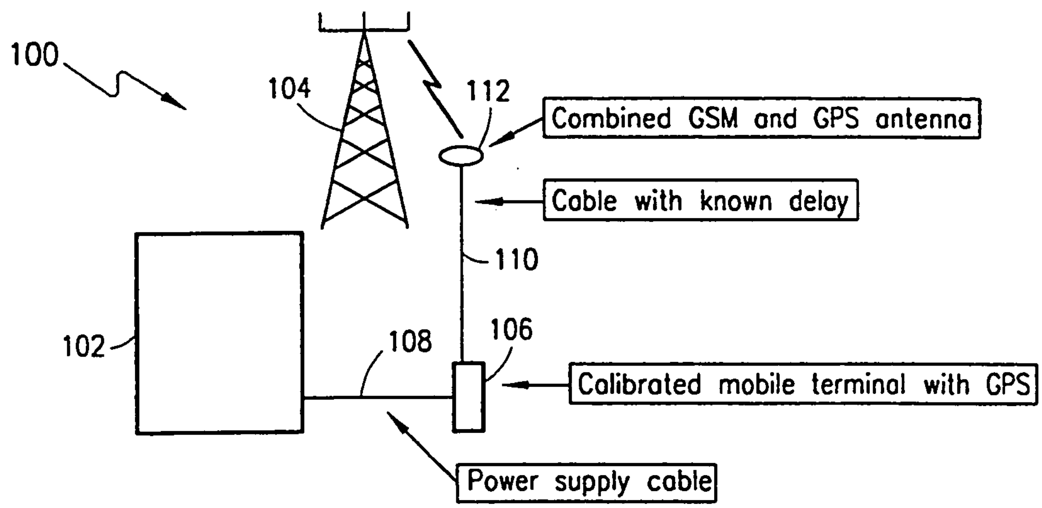

FIG. 2

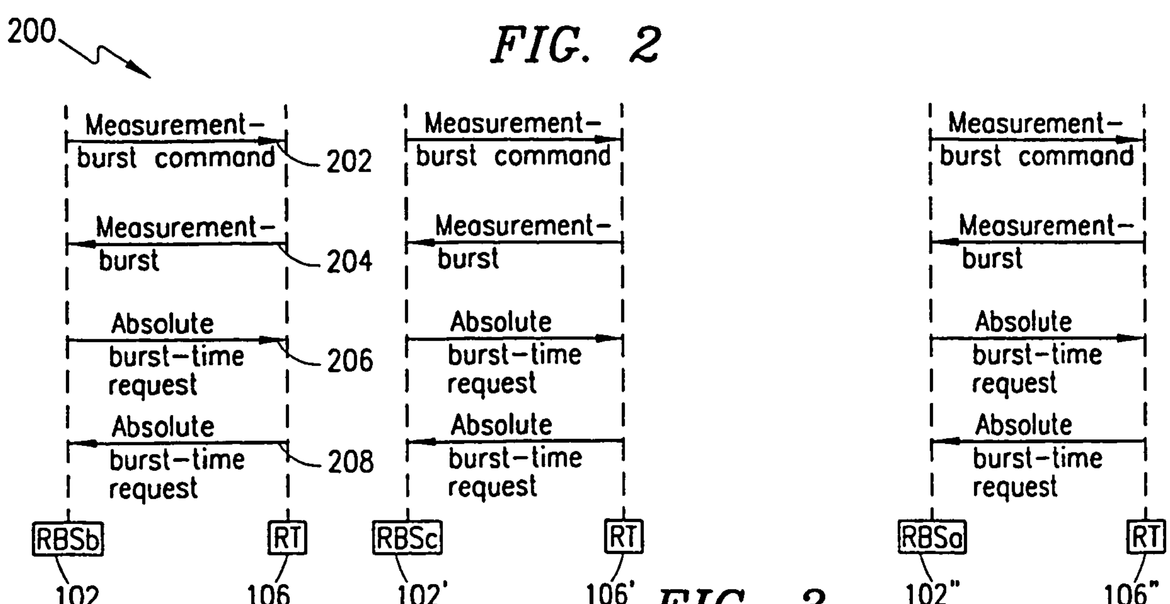

FIG. 3


300
Geo. position request
Geo. position response
302
304
RBSb
102
RT
106
RBSc
102'
RT
106'
RBSa
102"
RT
106"

FIG. 4

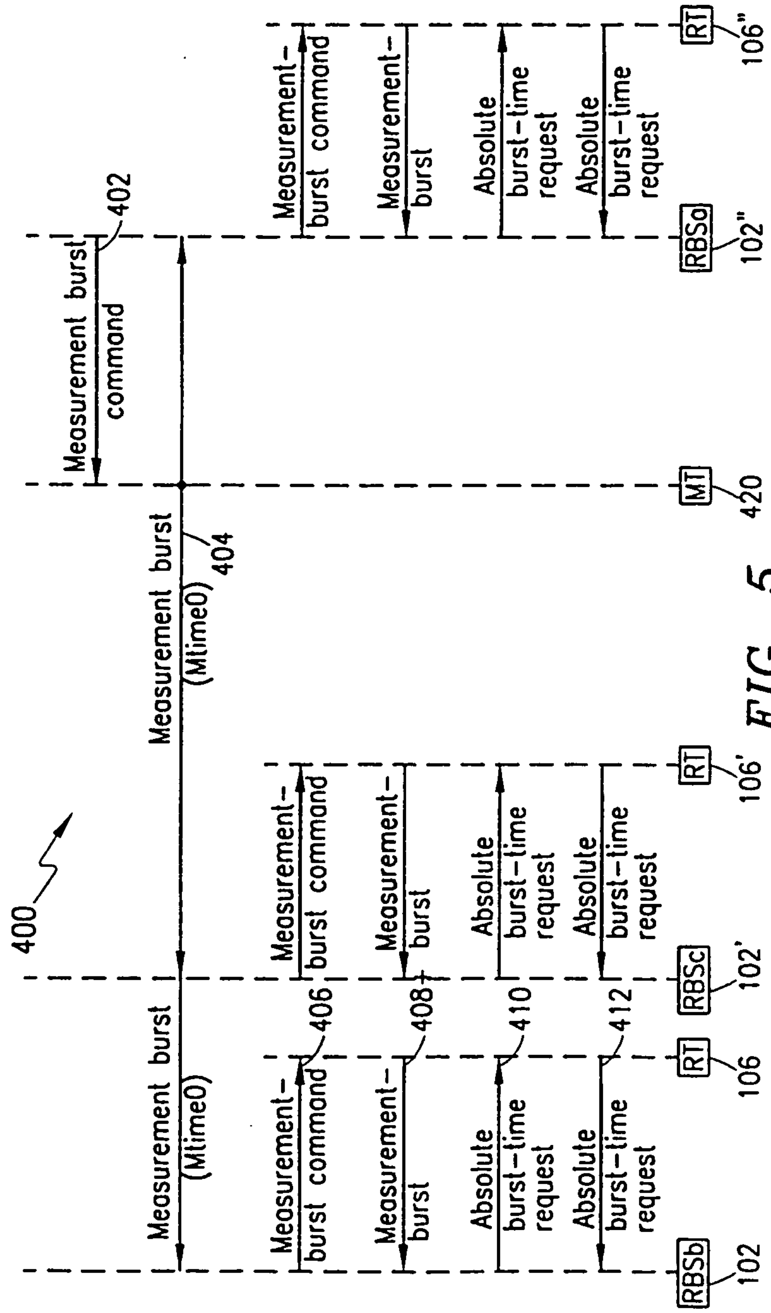
400
Measurement burst command
402
Measurement burst (Mtime0)
404
MT
420
Measurement-burst command
406
Measurement-burst
408
Absolute burst-time request
410
412
RBSb
102
RT
106
RBSc
102'
RT
106'
RBSa
102"
RT
106"

FIG. 5

INTERNATIONAL SEARCH REPORT

Internal Application No
PCT/SE 99/00579

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04B7/26 H04J3/06 G01S5/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G01S H04B H04J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 245 634 A (AVERBUCH NIMROD) 14 September 1993 (1993-09-14)	1,3,5
Y	column 3, line 22 - column 4, line 57	7,8
A	claims 1,3,4	15,18
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A	column 2, line 6 - line 29 column 4, line 67 - column 5, line 29 column 7, line 2 - line 36 column 8, line 35 - line 59 claims 1,2	1-7,9-15
Y	GB 2 277 232 A (MOTOROLA INC) 19 October 1994 (1994-10-19)	7
A	page 1, line 5 - line 16 page 2, line 20 - line 24 page 3, line 1 - page 4, line 6	12,20

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"&" document member of the same patent family

Date of the actual completion of the international search

13 August 1999

Date of mailing of the international search report

23/08/1999

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International Application No
PCT/SE 99/00579

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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A	US 5 481 258 A (FAWCETT GLENN S ET AL) 2 January 1996 (1996-01-02) the whole document	1-23

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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PCT/SE 99/00579

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